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Treatment Efficiencies of Constructed Wetlands for Eutrophic Landscape River Water*[1]

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ABSTRACT

The efficiencies of two types of constructed wetlands for the treatment of low-concentration polluted eutrophic landscape river water were studied in the western section of the Qingyuan River at the Minhang campus of Shanghai Jiaotong University. The first wetland was a single-stage system using gravel as a filtration medium, and the second was a three-stage system filled with combinations of gravel, zeolite, and fly ash. Results from parallel operations of the wetlands showed that the three-stage constructed wetland could remove organics, nitrogen, and phosphorus successfully. At the same time, it could also decrease ammoniacal odour in the effluent. Compared to the single-stage constructed wetland, it had better nutrient removal efficiencies with a higher removal of 19.37%–65.27% for total phosphorus (TP) and 21.56%–62.94% for total nitrogen (TN), respectively, during the operation period of 14 weeks. In terms of removal of chemical oxygen demand (COD), turbidity, and blue-green algae, these two wetland systems had equivalent performances. It was also found that in the western section of the test river, in which the two constructed wetlands were located, the water quality was much better than that in the eastern and middle sections without constructed wetland because COD, TN, and TP were all in a relatively lower level and the eutrophication could be prevented completely in the western section.

Key Words: constructed wetland, eutrophic landscape river, water treatment

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INTRODUCTION

With the rapid economic development of China, the urban landscape water quality standards are becoming more and more stringent and the number of artificial lakes and ponds in many places is increasing. Due to wastewater discharge and rainstorm runoff, most urban landscape water is polluted with low-concentration organic compounds (Liu *et al.*, 2003; Zhuo *et al.*, 2003). In addition, the water is stagnant and its ecosystem is simple, which makes oxygen transfer difficult and self-purification performance poor in closed water bodies (Li *et al.*, 2004). Therefore, nitrogen and phosphorus tend to accumulate, which results in propagation of blue-green algae, poor transparency, and malodour of the water. Currently, soil infiltration technology is frequently used to treat landscape water with low-concentration pollution (Rasiah *et al.*, 1995; David *et al.*, 1996; Eldridge *et al.*, 2000; Laura *et al.*, 2000; Lang *et al.*, 2002; Yan and Wang, 2003). This technology has the characteristics of low energy consumption, excellent removal of organics and suspended solids, and favourable ecological and landscape benefits, giving it great potential for the treatment of eutrophic landscape river water with low-concentration pollution (Zou *et al.*, 2003; Sheila and Robert, 2007; Siriwardene *et al.*, 2007). However, there still exist some limitations to the technology, such as poor removal of phosphorus and nitrogen, and this has largely limited its application. Therefore, more efficient filter medium has been developed to enhance the removal efficiencies (He and Huang, 2001; Ai *et al.*, 2005; Yan *et al.*, 2005; He *et al.*, 2007; Zadaka

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et al., 2007; Kaoru *et al.*, 2007).

From January to December of 2003, a horizontal-flow constructed wetland using gravel as a filtration medium was applied to treat landscape river water in the Minhang campus of Shanghai Jiaotong University (He, 2004). It was found that turbidity, chemical oxygen demand (COD) and blue-green algae could be significantly removed with efficiencies of 60.2%–68%, 30%–46.6%, and 80%–85%, respectively; whereas, the removal of nitrogen and phosphorus was poor, only 15.1%–20.4% and 5.8%–14.3%, respectively, during the initial operation period of two months, and became even worse with time. Phosphate concentration in effluent was sometimes even higher than that in influent because of the release of phosphorus contained at granules retained in the wetland. At the same time, oxygen in influent was consumed completely in the constructed wetland, and an obvious ammoniacal odour in the effluent could be detected.

In this study, two types of horizontal-flow wetlands were reconstructed to treat eutrophic landscape river water in parallel in order to improve the performance of the constructed wetlands and the efficiencies of these two types of constructed wetlands in treating eutrophic landscape river water with low-concentration pollution were compared.

MATERIALS AND METHODS

The Qingyuan River constructed for floodwater discharge is located at the Minhang campus of Shanghai Jiaotong University. It is divided into three sections by the construction of roads. The eastern section has a length of 180 m, the middle section 285 m, and the western section 207 m, with volumes of 3 200, 5 100, and 3 700 m^3, respectively. These three sections are connected together by concrete pipes buried under the roads. The downstream sluice gate is closed most of time, making the river water stagnant.

In January 2003, two wetlands were constructed in the western section of the Qingyuan River. Each wetland had the same size of 25 m × 0.7 m × 0.8 m (length × width × height) and a treatment capacity of 60 m^3 d^{-1}. The filter medium used to fill single-stage wetland (Wetland I) was gravel with size of 8–10 cm. In the first 10 m of the three-stage wetland (Wetland II), the filter medium used was also gravel, while the next 7 m was filled with zeolite of size 3–5 cm, and the last 7 m was filled with fly ash with a mean diameter of 5 cm. Two sampling wells with a width of 0.5 m were constructed between these three stages. Raw water was pumped into an influent well and then allowed to flow into the constructed wetlands. The treated water was then allowed to flow back into the Qingyuan River. The diagram and the cross sections of the two wetlands are presented in Fig. 1.

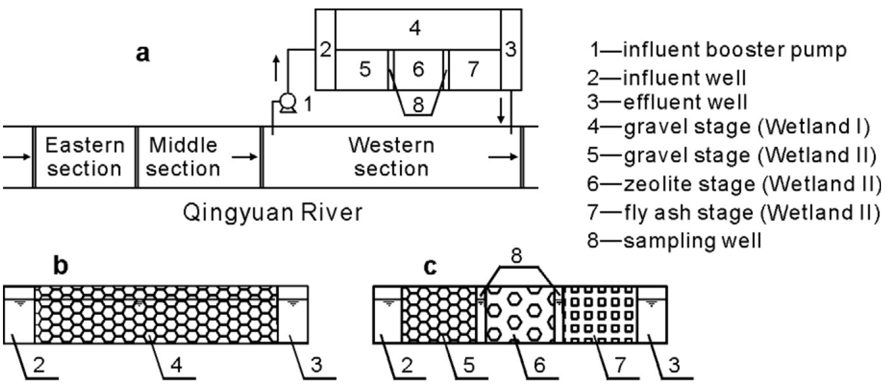

Fig. 1 Diagram (a) and cross sections of the single-stage (b) and the three-stage (c) constructed wetlands in the western section of the Qingyuan River.

In 2003, the Qingyuan River water quality was investigated throughout the year. The test water was collected from the western section of the Qingyuan River every week during the period of operation